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IWSM MENSURA 2012

# A Refined FSM Procedure for Real-Time Embedded Software Requirements Expressed using the Simulink Model

H. Soubra, A. Abran, A. Ramdane-Cherif

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# Agenda

- Background: FSM under Simulink
- Research issue
- Analysis & Proposed solution
- Conclusions


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# Background: FSM under Simulink

- In 2011, a COSMIC based FSM procedure for RTES software documented using the Simulink model was proposed (Soubra *et al.* IWSM-MENSURA, Nara, 2011).

- The background study for this procedure was conducted at Renault SA using Electronic Control Unit SW functional requirements expressed with the Simulink tool.

- The design of the FSM procedure is based on the mapping of key concepts in Simulink & COSMIC ISO 19761.


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# Background: FSM under Simulink

- The procedure was automated initially via a prototype tool -developed to demonstrate the feasibility of such automation.

- An industrial tool based on the prototype was presented by Renault at the MathWorks Automotive Conference in April 2012 (Stuttgart).


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# Background: The identified research problem with the old procedure

- The procedure provides the rules for obtaining the functional size of software and reducing the measurement variance caused by the interpretations of individual measurers…**BUT!**

- … the proposed procedure does not cover measurement variance caused by different design input models made by different designers which implement the same functional requirements.


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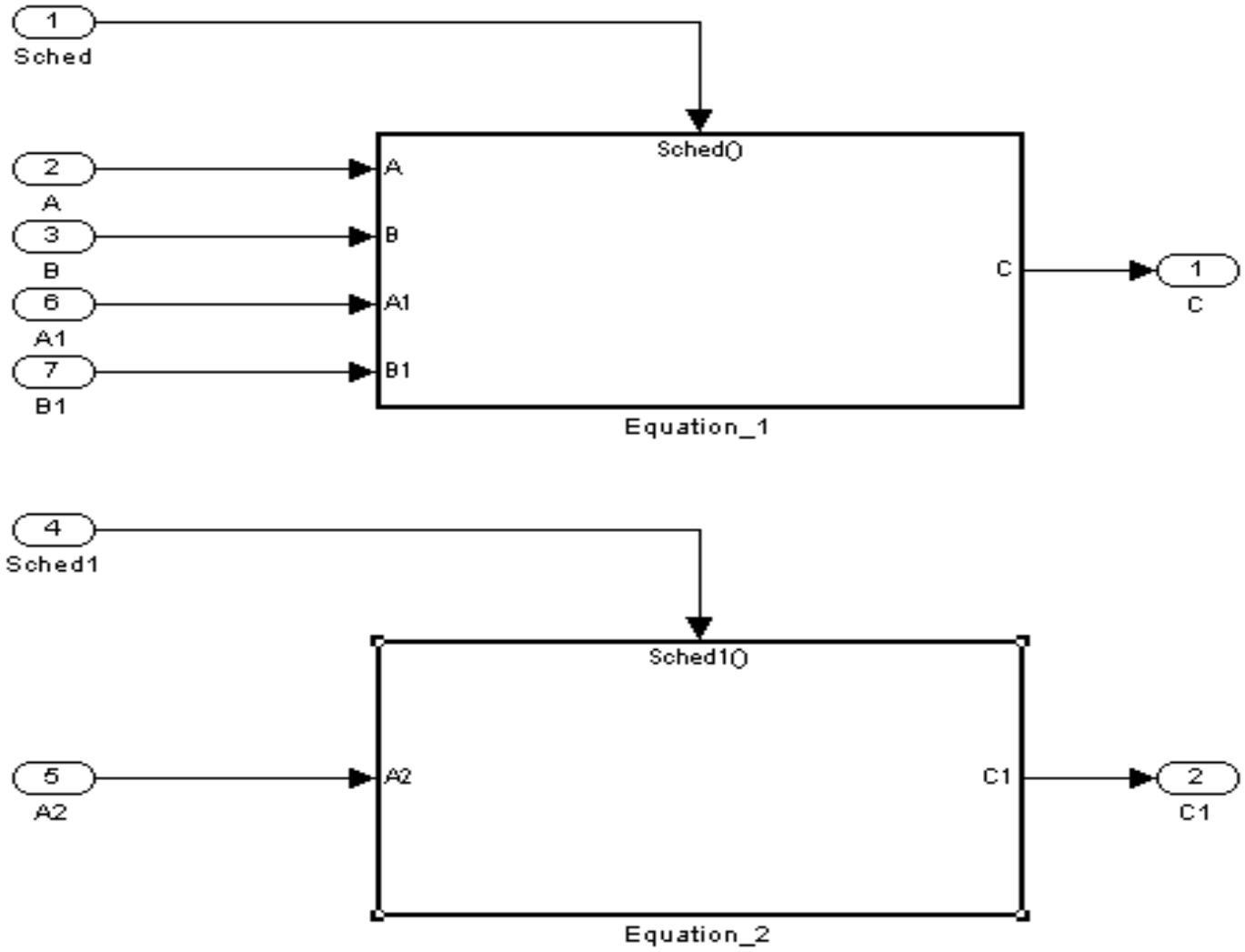
# The research problem – Example 1/8





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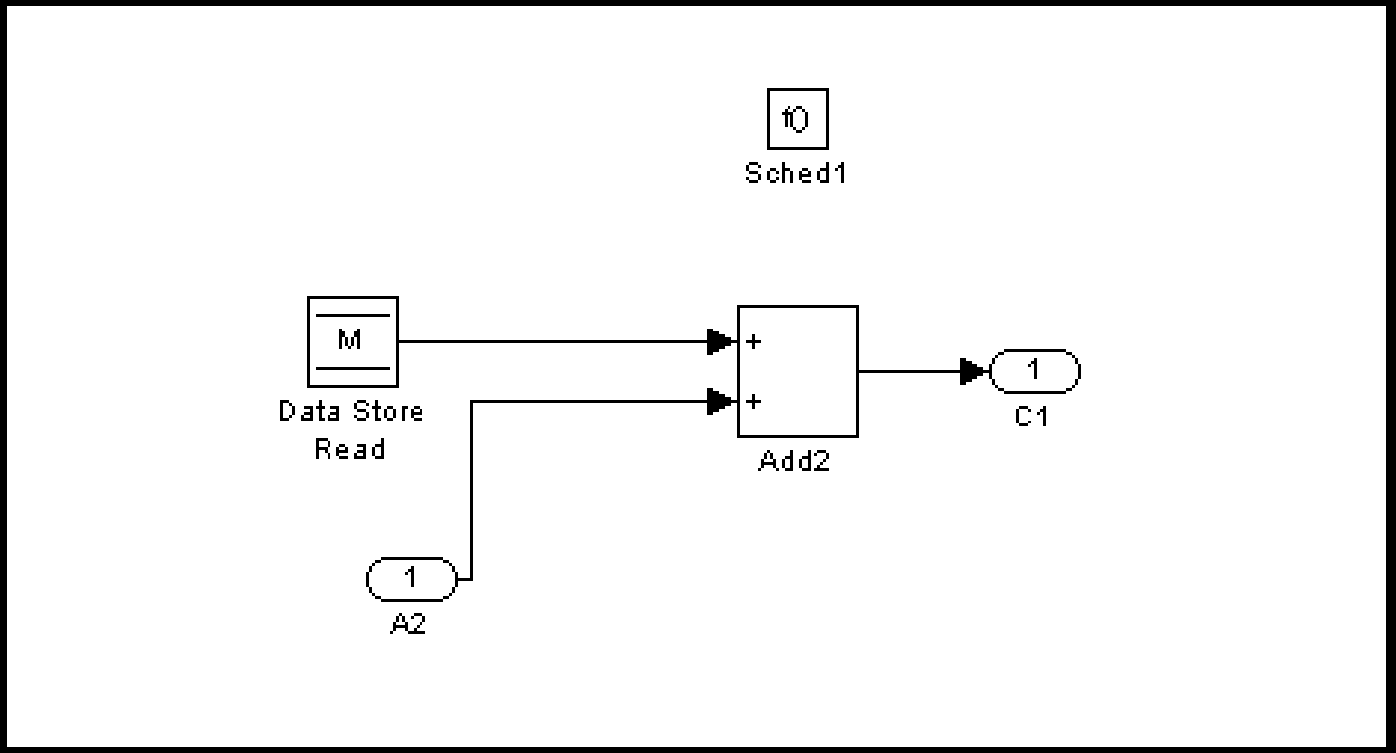
# The research problem – Example 2/8

Inside the Equation_2 Subsystem – **Version 1 & Version 2** (unchanged)





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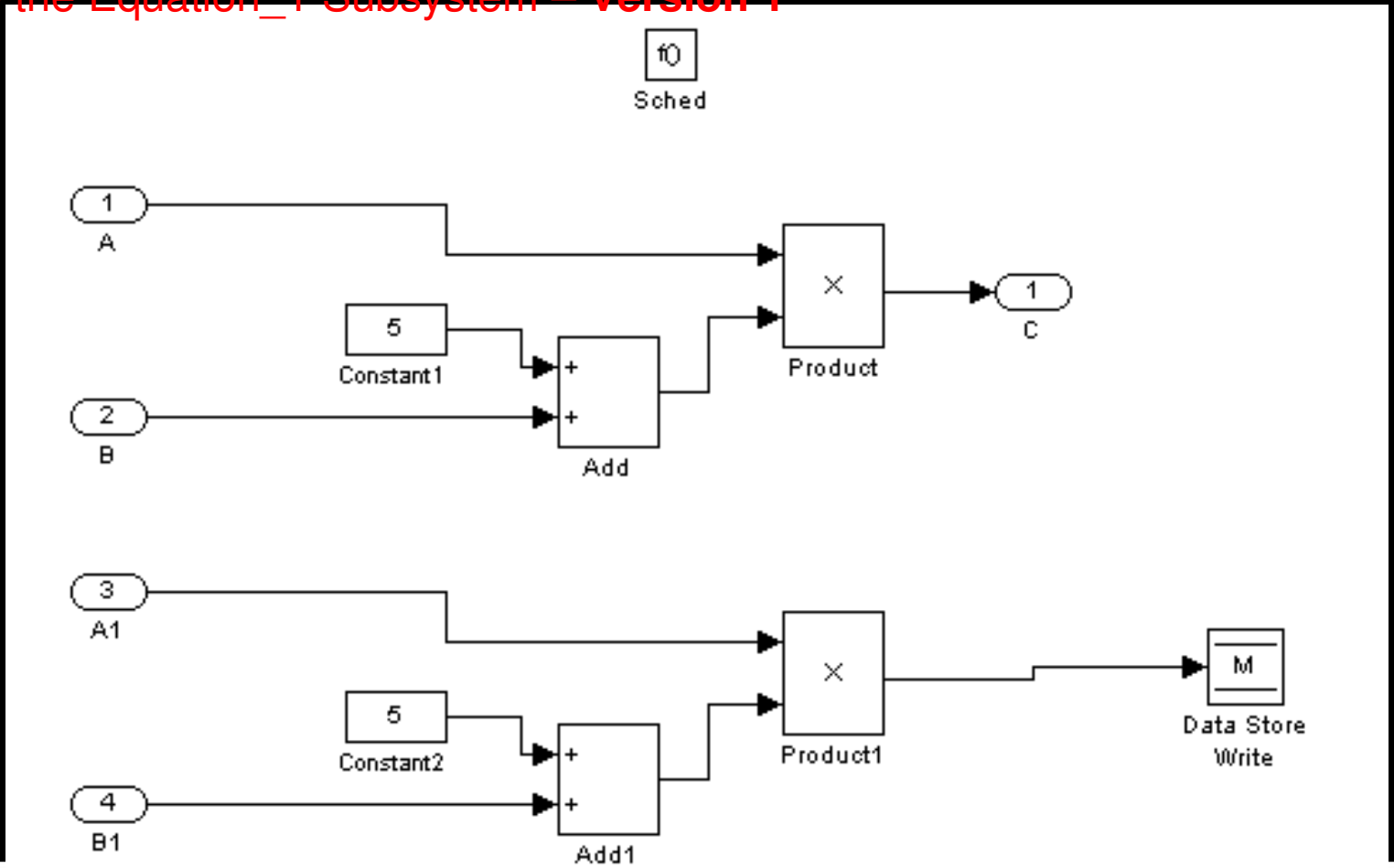
# The research problem – Example 3/8

Inside the Equation_1 Subsystem – **Version 1**





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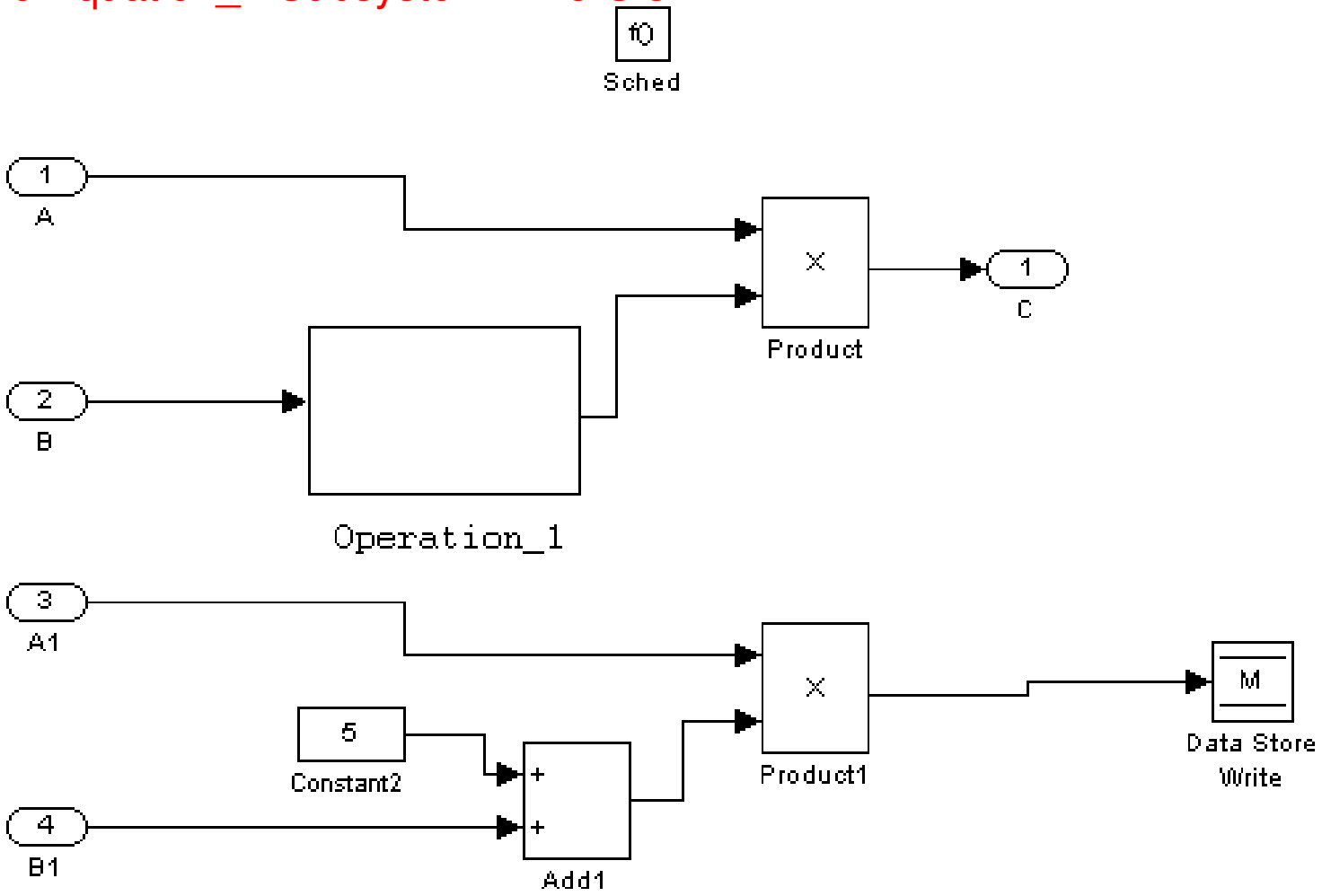
# The research problem – Example 4/8

Inside the Equation_1 Subsystem – **Version 2**





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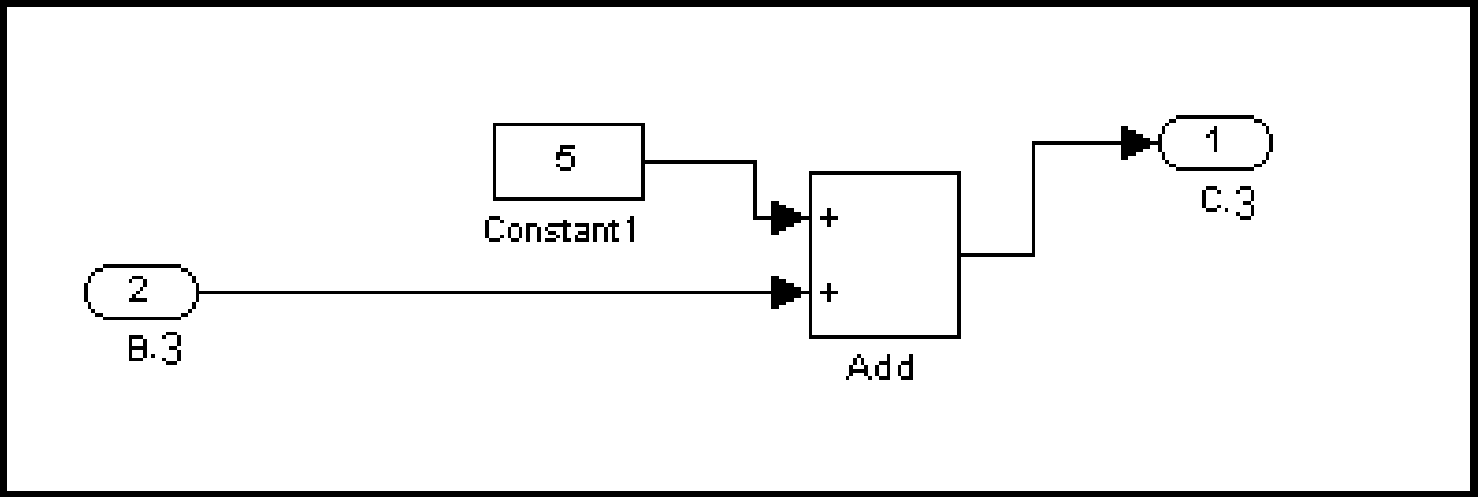
# The research problem – Example 5/8

Inside the Operation_1 Subsystem





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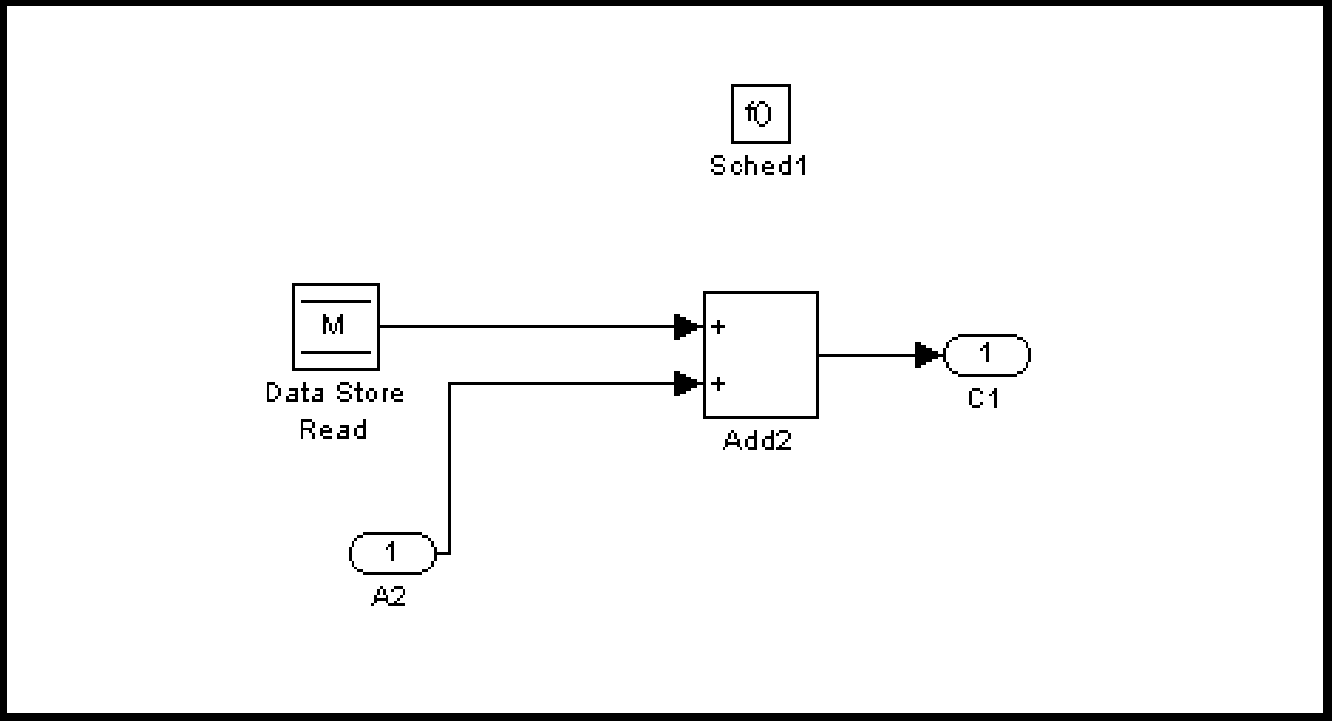
# The research problem – Example 6/8

## Functional size difference between the 2 models:

Equation_2– **Version 1& 2**: 4 CFP





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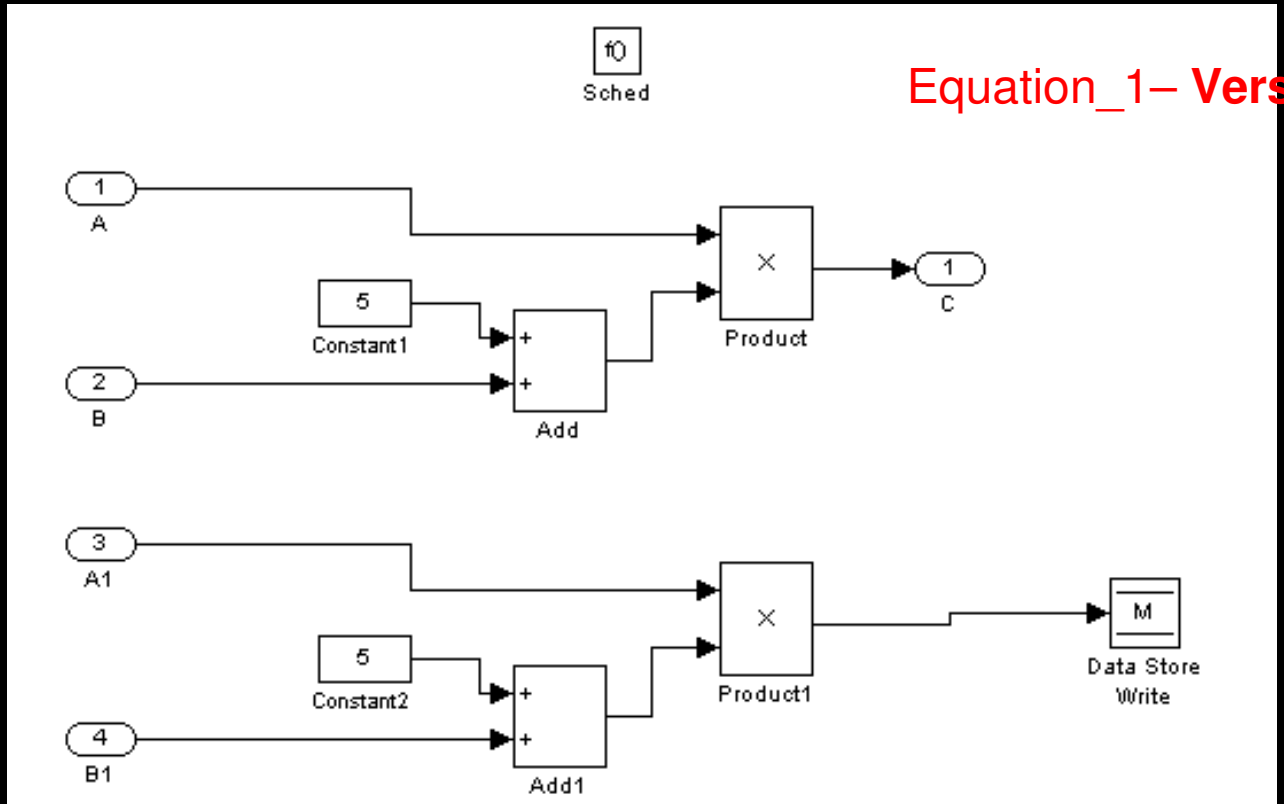
# The research problem – Example 7/8

## Functional size difference between the 2 models:




Equation_1– **Version 1**: 9 CFP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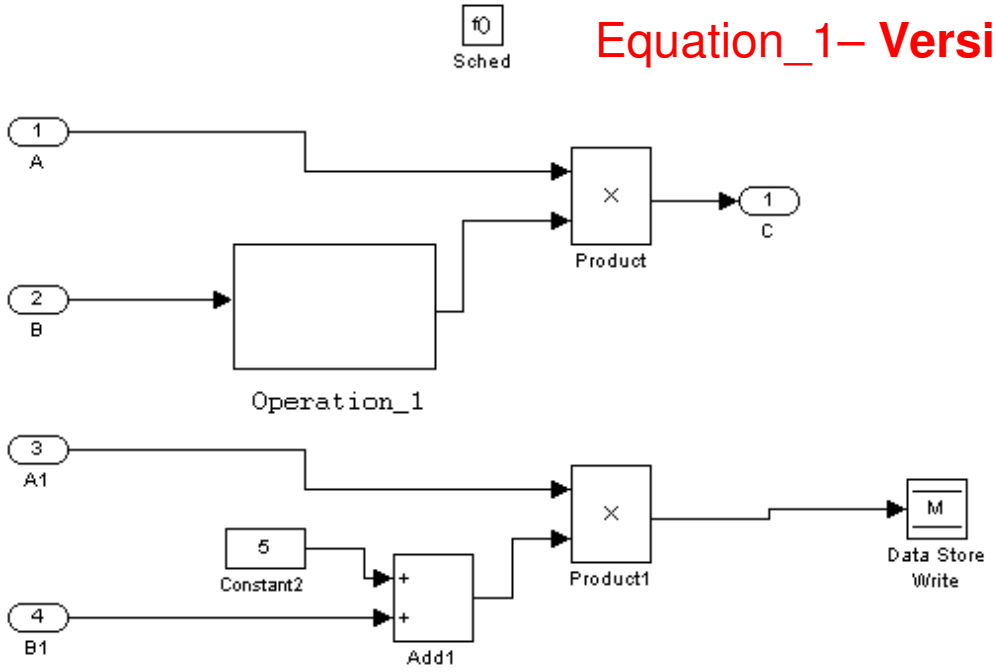
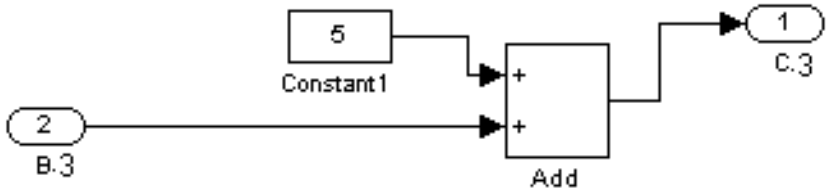
# The research problem – Example 8/8

## Functional size difference between the 2 models:

Equation_1– **Version 2**: 8 CFP




Operation_1: 3 CFP





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# The research problem – Example Size difference

Functional size difference between the 2 models:

Version 1: 13 CFP

- Size of Equation_1 functional process = 9 CFP.
- Size of Equation_2 functional process = 4 CFP.

Version 2: 15 CFP

- Size of Equation_1 functional process = 8 CFP.
- Size of Operation_1 functional process = 3 CFP
- Size of Equation_2 functional process = 4 CFP.

**Same functional requirements, different layouts: measurement difference of 2 CFP!!!**


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# Analysis 1/5

- The old FSM procedure maps subsystem blocks to identify Functional Processes **without** examining the nature of the subsystem block itself (virtual or not).

- A virtual subsystem block is used to group blocks so that fewer of them are displayed in the designer's modeling window, unless it is set to be treated as an atomic unit.


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# Analysis 2/5

- The primary characteristic of an atomic subsystem is that its blocks execute as a single unit. This provides the advantage of grouping the functional aspects of models at the execution level.

- A conditionally executed subsystem is a subsystem whose execution depends on the value of an input signal.


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# Analysis 3/5

- Another issue concerns the so-called “elementary blocks” used to identify the data group movements in the rules of the old FSM procedure, without any distinction made as to the nature of the blocks themselves.

- All elementary blocks are defined as functional ones. This is not true for all blocks found in the library:
  - some of the blocks are merely used to simplify model layouts and to help organize a model graphically - they play no active role in the model’s behavior .


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# Analysis 4/5

- It is more natural to map only conditionally executed subsystem blocks and atomic units as functional processes, rather than all subsystems, including the virtual ones, as suggested in the old FSM procedure.

- The new FSM procedure should no longer be dependent on virtual subsystems, which are strongly related to layout and visualization issues, and the functional size result will be more accurate.


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# Analysis 5/5

- It would be more appropriate to introduce a block category called “Functional blocks,” which contain only non virtual blocks manipulating input data and yielding output data to other blocks.

- The Functional blocks category introduced in our paper contains all the non virtual blocks found in the Simulink Library or created by Simulink users.

- Functional blocks can only be non virtual and must have both input(s) and output(s).


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# Solution: A refined FSM 1/2

- Mapping phase: **only non virtual subsystem blocks** (i.e. conditionally executed subsystem blocks and atomic units) containing a ***functional block*** are functional processes.

- Measurement phase: **non virtual functional blocks** are used for correctly identifying the 4 types of COSMIC data movements.


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# Solution: A refined FSM 2/2

- As for the blocks that are defined under virtual subsystem blocks: their trigger follows the last atomic unit in which their virtual subsystem block is defined, if this atomic unit is defined.

- If not, all these blocks are considered to be in 1 single functional process, called the *Default Functional Process*.


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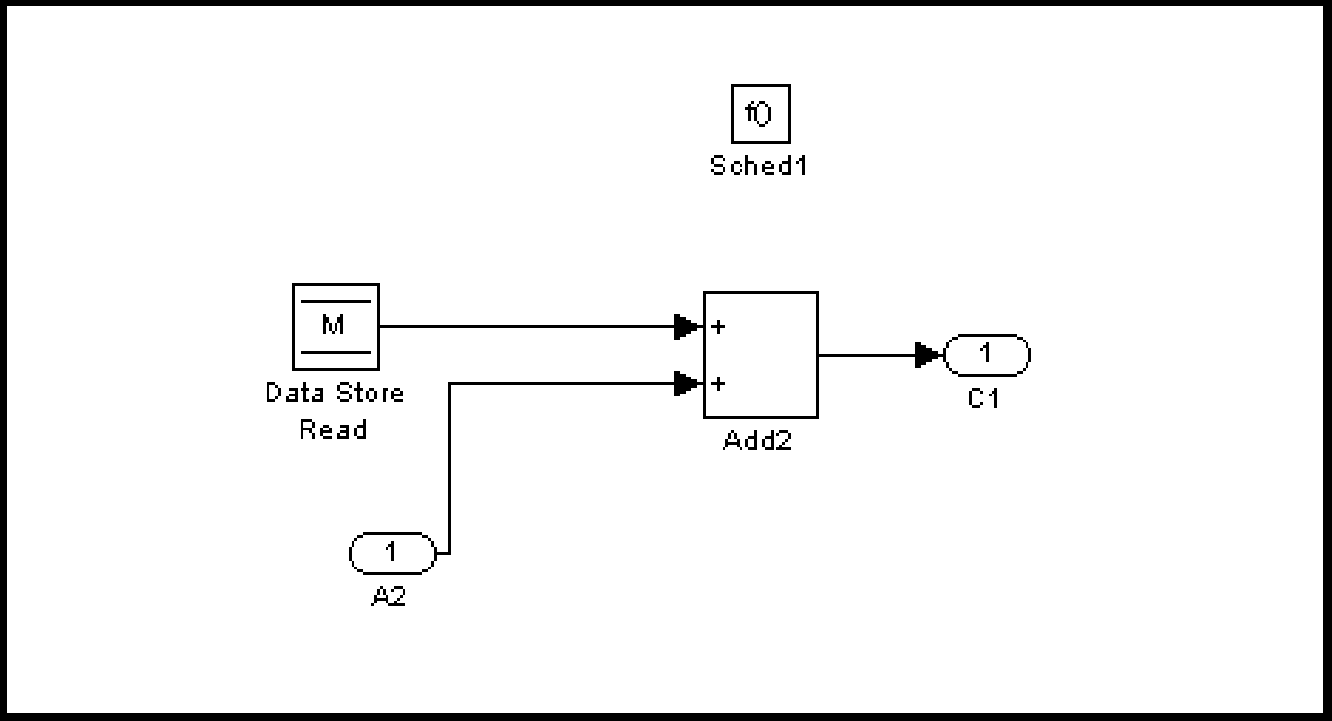
# Measuring the Equation system with the new refined FSM

## Functional size difference between the 2 models:

Equation_2– **Version 1& 2**: 4 CFP





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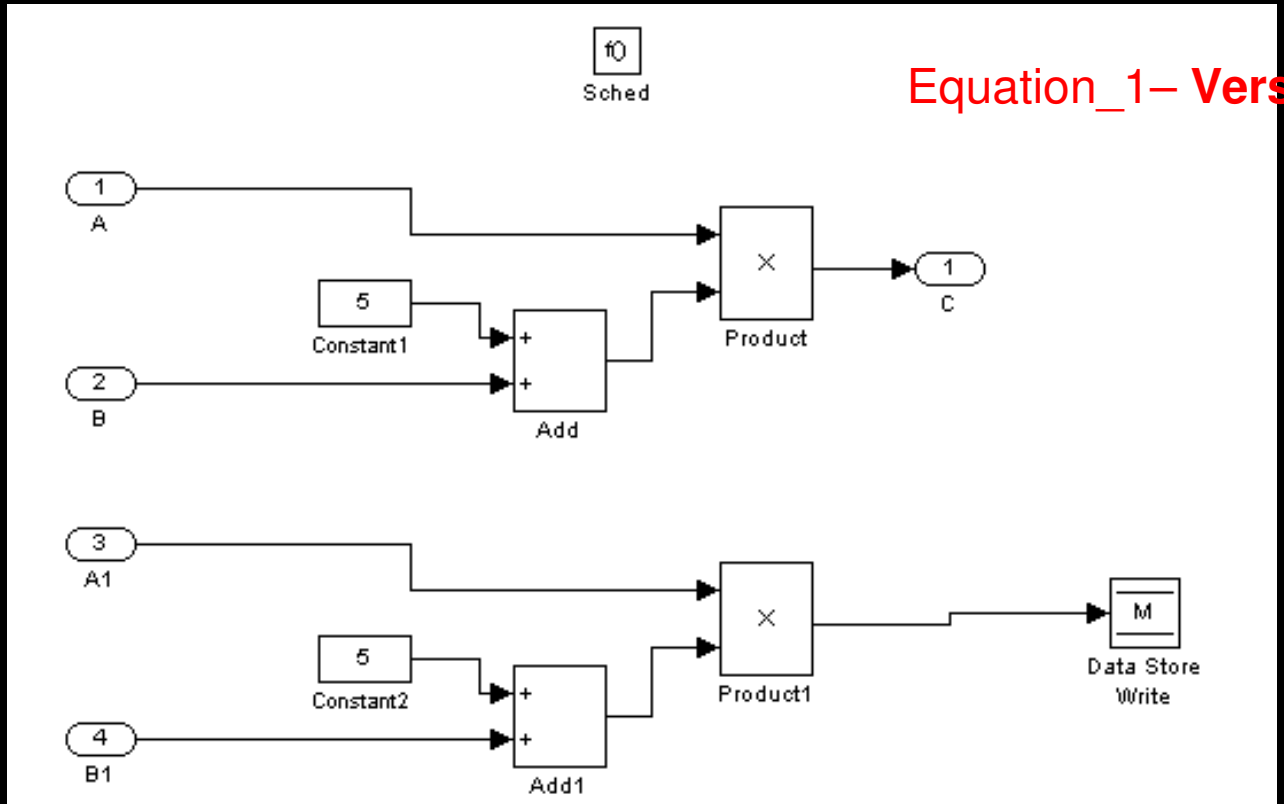
# Measuring the Equation system with the new refined FSM

## Functional size difference between the 2 models:




Equation_1– **Version 1**: 9 CFP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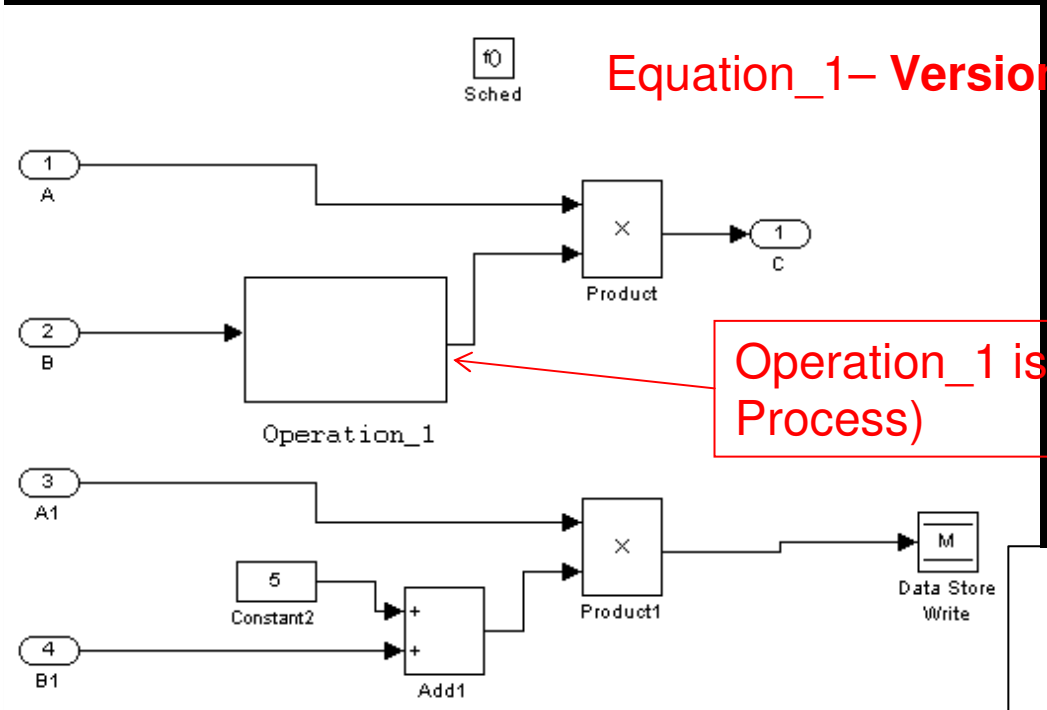
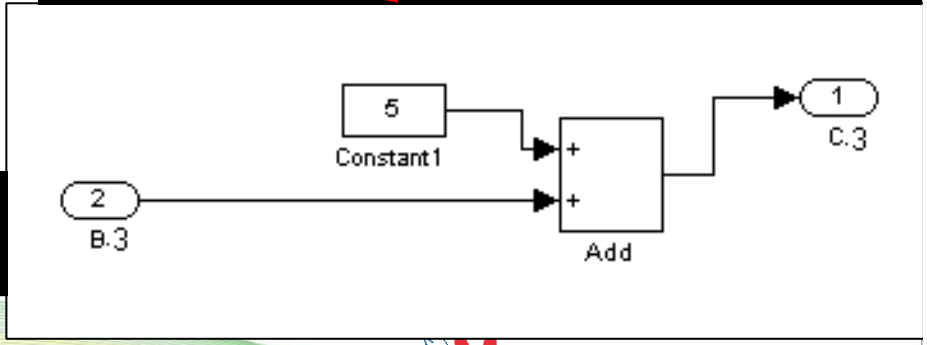
# Measuring the Equation system with the new refined FSM

## Functional size difference between the 2 models:




Equation_1– **Version 2**: 9 CFP

Operation_1 is no longer identified as a Functional Process)





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# Measuring the Equation system with the new refined FSM

Functional size difference between the 2 models:

Version 1: 13 CFP

- Size of the Equation_1 functional process = 9 CFP.
- Size of the Equation_2 functional process = 4 CFP.

Version 2: 13 CFP

- Size of the Equation_1 functional process = 9 CFP.
- Size of the Equation_2 functional process = 4 CFP.

Same requirements, different layouts: No measurement difference


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# Conclusions

- Functional sizes obtained when applying COSMIC-based FSM procedures should not vary, even when different models of the same software are measured.

- FSM procedures should be designed to be independent of any implementation decisions made in the operational artifacts of the software to be measured.

- So, 2 different models implementing the same system with the same functional requirements should have exactly the same functional size.

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# Conclusions

- In this paper, revised rules of a refined FSM procedure for real-time embedded software requirements documented using the Simulink modeling tool have been proposed to tackle the issue of measurement variance, and guidelines and a case study have been included as well.

- The revised rules prevent ambiguities and help reduce the discrepancies between different models made by different designers of the same software application.

- The objective has been to provide a foundation for more accurate functional size results.

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# Q & A

hassan.soubra@estaca.fr

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